and the second refurbishing element **70**(*b*) is the other of the pad conditioner or the pad cleaner so that the second refurbishing element **70**(*b*) is not the same as the first refurbishing element **70**(*a*). In a preferred embodiment, the first cleaning element **70**(*a*) is a pad cleaner and the second cleaning element **70**(*b*) is a pad conditioner to prevent large particles separated from the pad by the pad conditioner **70**(*b*) from engaging the surface of the wafer **12**. In this embodiment, therefore, the polishing pad **40** may be selectively conditioned and cleaned in situ and in real-time with the same apparatus. The pad refuirbisher **150** illustrated in FIG. **5** operates in the same manner as the pad refurbisher illustrated in FIG. **2**, and parts having the same reference numbers in FIGS. **2** and **5** perform the same functions.

In another embodiment, the inner and outer rings **61**(*a*) and **61**(*b*), respectively, of pad refurbisher **150** illustrated in FIG. **5** operate independently from one another. A first actuator (not shown) may be operatively attached to only the inner ring **61**(*a*) and a second actuator (not shown) may be operatively attached to only the outer ring **61**(*b*). The inner and outer rings **61**(*a*) and **61**(*b*) are accordingly separated from one another (not shown) so that they may independently engage the polishing surface **42** of the polishing pad **40**.

One advantage of the pad refurbishers **50** and **150** of the present invention is that they selectively condition and/or clean generally only the deteriorated areas on the polishing surface that need to be brought back to an acceptable polishing condition. By attaching the pad refurbisher to the wafer carrier so that the refurbishing element travels with the wafer carrier, and by controlling the vertical motion of the refurbishing element with respect to the wafer carrier, the refurbishing element may be selectively engaged with the deteriorated areas on the pad. Moreover, by positioning the refurbishing element proximate to the wafer carrier, only a slightly larger area than that of the wafer carrier is conditioned or cleaned even when the refurbishing element continuously engages the pad. Therefore, compared to conventional conditioners, the pad refurbisher of the present invention reduces over-conditioning of areas on the polishing surface that do not require conditioning or cleaning.

Another advantage of the present invention is that the pad refurbishers **50** and **150** condition and/or clean a polishing surface of a polishing pad in situ and in real-time while a wafer is planarized. Since the cleansing element **70** may be selectively engaged and disengaged with the polishing pad from the wafer carrier **30**, the wafer **12** may be polished while the polishing surface **42** of the pad **40** is conditioned and/or cleaned. Thus, compared to some conditioning devices that cannot simultaneously condition the pad and polish the wafer, the pad refurbisher **50** enhances the throughput of the CMP process because the down-time to condition and clean the polishing pad is significantly reduced or even eliminated.

From the foregoing it will be appreciated that, although specific embodiments of the invention have been described herein for purposes of illustration, various modifications may be made without deviating from the spirit and scope of the invention. For example, the apparatus and method may also be used in chemical-mechanical polishing of other microelectronic substrates, such as field emission displays, in addition to semiconductor wafers. Accordingly, the invention is not limited except as by the appended claims.

We claim:

1. A pad refurbisher for in situ, real-time refurbishing of a polishing surface on a polishing pad used in chemical-mechanical polishing of a semiconductor wafer, comprising:

a body adapted for attachment to a wafer carrier of a chemical-mechanical polishing machine with the body having a face positioned proximate to a perimeter portion of the wafer carrier and facing the polishing surface of the polishing pad, the body being adapted to travel with the wafer carrier as the wafer carrier moves over the polishing pad wherein the body is movably attached to the wafer carrier; and

a refurbishing element connected to the face of the body, the refurbishing element being adapted to engage the polishing surface substantially adjacent to the perimeter portion of the wafer carrier and traveling with the wafer carrier while the wafer carrier moves the wafer over the polishing surface.

2. The pad refurbisher of claim **1** wherein the body is fixed to the wafer carrier.

3. The pad refurbisher of claim **1** wherein the body is slidably attached to the wafer carrier.

4. The pad refurbisher of claim **3**, further comprising a linear actuator attached to the body, wherein the actuator independently moves the body with respect to the wafer carrier along an axis substantially normal to the polishing surface to selectively engage the refurbishing element with areas on the polishing surface in need of cleansing and to selectively disengage the refurbishing element from areas on the pad in adequate condition.

5. The pad refurbisher of claim **1** wherein the face is a distal face of the body defining a ring positioned radially outwardly from the perimeter of the wafer carrier.

6. The pad refurbisher of claim **1** wherein the body has a plurality of arcuate segments positioned radially outwardly from the perimeter of the wafer carrier, the arcuate segments being spaced apart from one another around the wafer carrier and each arcuate segment having a distal face facing generally towards the polishing surface of the polishing pad.

7. The pad refurbisher of claim **1** wherein the refurbishing element is a brush comprising a plurality of bristles extending downwardly from the face towards the polishing surface, the bristles engaging the polishing surface to clean waste particles from the pad.

8. The pad refurbisher of claim **1** wherein the refurbishing element is a pad conditioner that removes a layer of pad material from polishing surface of the pad to form a new polishing surface on the polishing pad.

9. The pad refurbisher of claim **8** wherein the pad conditioner comprises a pad with a plurality of embedded diamonds, the pad being connected to the distal surface of the body.

10. The pad refurbisher of claim **1** wherein the body has a first ring with a first refurbishing element and a second ring with a second refurbishing element, the first ring being positioned radially outwardly from the perimeter of the wafer carrier and the second ring being positioned radially outwardly from the first ring.

11. The pad refurbisher of claim **10** wherein the first refurbishing element is a pad cleaner and the second refurbishing element is a pad conditioner.

12. The pad refurbisher of claim **1** wherein the body is adapted to be symmetrically positioned about the center of the wafer carrier.

13. A polishing machine for chemical-mechanical polishing of a semiconductor wafer, comprising:

a platen having an upper surface;

a polishing pad positioned on the upper surface of the platen, the polishing pad having a polishing surface facing away from the platen;

a wafer carrier for carrying the wafer, the wafer carrier being positioned over the polishing pad and moveable

along an axis substantially normal to the upper surface of the platen to engage the wafer with the polishing pad, wherein at least one of the platen and the wafer carrier moves with respect to the other to impart relative motion between the wafer and the polishing pad; and

a pad refurbisher having a body with a face positioned proximate to a perimeter portion of the wafer carrier and facing generally towards the polishing surface and a refurbishing element connected to the face, the body being attached to the wafer carrier so that the body and refurbishing element travel with the wafer carrier as the wafer carrier moves with respect to the polishing pad, wherein the refurbishing element engages the polishing surface substantially adjacent to the perimeter portion of the wafer carrier while the wafer carrier moves the wafer over the polishing surface and wherein the body is movably attached to the wafer carrier.

14. The polishing machine of claim **13** wherein the body is fixed to the wafer carrier.

15. The polishing machine of claim **13** wherein the body is slidably attached to the wafer carrier.

16. The polishing machine of claim **15**, further comprising a linear actuator attached to the body, wherein the actuator independently moves the body downwardly and upwardly with respect to the wafer carrier along an axis substantially perpendicular to the polishing surface to selectively engage the refurbishing element with areas on the polishing surface in need of cleansing and to selectively disengage the refurbishing element from areas on the pad in adequate condition.

17. The polishing machine of claim **13** wherein the face of the body is a ring positioned radially outwardly from the perimeter of the wafer carrier.

18. The polishing machine of claim **13** wherein the body has a plurality of arcuate segments positioned radially outwardly from the perimeter of the wafer carrier, the arcuate segments being spaced apart from one another around the wafer carrier and each arcuate segment having a distal face facing generally towards the polishing surface of the polishing pad.

19. The polishing machine of claim **13** wherein the refurbishing element is a brush comprising a plurality of bristles extending downwardly from the face towards the polishing surface, the bristles engaging the polishing surface to clean waste particles from the pad.

20. The polishing machine of claim **13** wherein the refurbishing element is a pad conditioner that removes a layer of pad material from polishing surface of the pad to form a new polishing surface on the polishing pad.

21. The polishing machine of claim **20** wherein the pad conditioner comprises a pad with a plurality of embedded diamonds, the pad being connected to the distal surface of the body.

22. The polishing machine of claim **13** wherein the body has a first ring with a first refurbishing element and a second ring with a second refurbishing element, the first ring being positioned radially outwardly from the perimeter of the wafer carrier and the second ring being positioned radially outwardly from the first ring.

23. The polishing machine of claim **13** wherein the first refurbishing element is a pad cleaner and the second refurbishing element is a pad conditioner.

24. The polishing machine of claim **13** wherein the pad refurbishing element is symmetrically positioned about the center of the wafer carrier.

25. A method for refurbishing a polishing pad, comprising the steps of:

providing a pad refurbisher having a body with a face positioned proximate to a perimeter portion of a wafer carrier of a chemical-mechanical polishing machine and facing generally towards the polishing surface, and a refurbishing element connected to the face of the body, the body being movably attached to the wafer carrier;

engaging the pad refurbishing element with the polishing pad; and

moving at least one of the wafer carrier and the polishing pad with respect to the other to pass the refurbishing element across the polishing pad.

26. The method of claim **25** wherein the engaging step comprises selectively lowering the body towards the polishing pad while the wafer carrier presses a wafer against the polishing pad and moves the wafer over the polishing pad to polish the wafer.

27. The method of claim **26** wherein the method further comprises selectively disengaging the refurbishing element from the pad.

28. The method of claim **26** comprises selectively engaging the refurbishing element with deteriorated portions of the polishing pad with accumulations of waste matter.

29. The method of claim **25** wherein the engaging step comprises lowering the wafer carrier until the refurbishing element and a wafer abut the polishing pad.

30. The method of claim **25** wherein the refurbishing element comprises a pad conditioner and a pad cleaner, and wherein the engaging step comprises pressing the pad conditioner and the pad cleaner against the polishing pad.

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